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CLIMATIC CHANGES

By C. E. P. Brooks, D.Sc.

Man, in his short life, rarely sees much change in his natural environment. That there have been great changes, however, the rocks themselves show, for almost everywhere the dry land was once part of the ocean floor. Likewise, within living memory changes of climate (as distinct from weather, which varies from year to year) have been barely appreciable without the aid of instruments, yet primitive man saw great ice sheets advance and retreat across England, where at still earlier periods coral reefs had fringed islands rich with sub-tropical plants.

The various periods recognised by geologists are set out in table I, which also gives their approximate ages in millions of years and brief indications of the prevailing geographical and climatic conditions. The story of the measurement of geological time is a romance in itself; the ages given here depend on determinations of the amounts of radio-active elements and their end-products —lead and helium—in lavas and similar rocks which were once molten(1).

The geological formations are divided into five unequal groups by the horizontal lines. The lowest, which includes a number of very old, altered and fragmentary formations, has a variety of names, of which " Pre-Cambrian " is the least controversial; the remaining four are known in ascending sequence as Palaeozoic, Mesozoic, Tertiary or Cenozoic, and Quaternary, the latter passing upwards into the deposits which are still in process of formation.

Age in million Years.	Formation.	Geographical Conditions.	Climate of Middle Latitudes.
	Recent ..	Mountainous, continental, volcanic.	Becoming warmer.
	Pleistocene		Glacial.
1	Pliocene ..		Temperate to cold.
15	Miocene ..	Local mountains ..	Sub-tropical.
34	Oligocene ..		Cooler.
50	Eocene ..	-Volcanic	Sub-tropical.
70	Cretaceous	Low ground, insular	Cooler.
110	Jurassic ..		Tropical to Sub-tropical.
140	Triassic ..		Sub-tropical.
190	Permian ..	Mountainous, Continental, volcanic.	Cool.
225	Carboniferous		Glacial, mainly in southern hemisphere.
270	Devonian ..	Low ground, insular	Tropical to Sub-tropical.
310	Silurian ..	Rather mountainous	Cooler.
340	Ordovician	Low ground, insular	Tropical to Sub-tropical.
390	Cambrian ..		
500		Mountainous, volcanic.	Glacial.
750–1500	Pre-Cambrian.		Unknown. Glacial ? Unknown. Glacial.
1750	Oldest known rocks.		

Table. I.—Geological Formations.

The geological record shows a series of great outbreaks of mountain building, alternating with long intervals during which the earth's crust was relatively steady. In these orogenic periods the crust was thrown into great folds, both above and below the surface of the sea. The waters retired into the hollows, leaving large continents with a high average elevation above sea level. After the disturbances ceased, the ordinary processes of weathering gradually wore down the mountains and carried the detritus into the oceans, which encroached upon the land. In this way the lofty continents were broken up into large relatively low islands.

The greatest periods of mountain building have occurred at intervals of about 250 million years, at the end of the Pre-Cambrian, in the Carboniferous and Plio-Pleistocene. The last column gives an outline of the climatic changes recorded in the rocks of what are now known as the "temperate" regions. The evidence for these changes is manifold; warm periods are indicated by the remains of plants and animals whose nearest living relatives are only found in low latitudes, by minerals in salt deposits which can only form at certain temperatures, by soil types, etc. The evidence for glaciation is provided mainly by grooved rocks, far-travelled boulders, moraines and tumbled deposits of a type familiar around the ice-sheets and glaciers of to-day. In the earliest deposits the few doubtful fossils are useless as a guide, so that apart from the existence of glaciers indicated by isolated vestiges at two or three levels, we have no evidence as to climatic changes, but from the Cambrian onwards the record becomes increasingly complete and reliable. Beginning with the topmost Pre-Cambrian there have been two great oscillations, from glacial to genial and back to glacial, each of which was interrupted by one or more relatively cool but not glacial periods. From the last Ice Age we have not yet completely emerged.

Table I shows a close parallelism between geography and climate. Each of the great epochs of mountain building was accompanied by widespread glaciation,

times of minor disturbance tended to be cool with local mountain glaciers, while during the quiet insular periods mild climates extended to high latitudes. The association of mountains with glaciation is readily understood; high ground with its low temperature and heavy snowfall is necessary for the development of glaciers, but this does not explain the general lowering of temperature which enables these glaciers to expand over the lowlands as great ice sheets. For this we must turn to three other factors which accompany folding of the crust. Probably most important is the formation of ridges of land connecting the continents and preventing the access of warm tropical waters to high latitudes. The effect of a land bar between Greenland and Scotland on the climate of Norway can readily be imagined and may have been one of the prime causes of the Quarternary glaciation of northern Europe. Secondly, in middle and high latitudes large land masses have a lower average temperature than islands, especially where the ground is covered by a persistent snow cover in winter, and this would aid the growth of the ice-sheets. Finally, crustal disturbance is commonly accompanied by volcanic action, and W. J. Humphreys(2) has shown that a veil of volcanic dust may be an effective agent in lowering the temperature. Conversely, the breaking up and partial submergence of the continents into large low islands means the free circulation of ocean currents from equator to poles, the absence of heavy snow and gathering grounds for glaciers, and a generally mild oceanic climate. Qualitatively the explanation is clear; elsewhere(3) I have endeavoured to show that it is also quantitatively sufficient.

There is one interesting point. At present the Arctic Ocean is mostly covered by a large sheet of floating ice. The air temperature is very low, but this is due mainly to the ice itself, and calculations show that if the ice could all be swept away, the "non-glacial" temperature would be only a few degrees below the freezing point of sea water. Of course the ice would form again, first as a small nucleus in the coldest area, and then more and

more rapidly as the growing ice-sheet cooled the air around it. But if the non-glacial temperature rose above the freezing point, once the ice was swept away it could not form again. During the oceanic periods, instead of a single Gulf Stream, two or three great currents warmed the Arctic, quite sufficient to raise the temperature well above freezing. With no ice to depress the temperature, a mild climate would prevail up to the Pole itself, permitting fairly rich vegetation at least on the shores of the islands.

There is one other terrestrial factor which may have had some effect on climate, namely the constitution of the atmosphere. There are two gases which strongly absorb long-wave radiation, namely water vapour and carbon-dioxide. During mild oceanic periods the moisture content of the atmosphere would be high, and this would tend to raise the temperature still further, but would be off-set to some extent by increased cloudiness. The amount of carbon-dioxide in the air has also varied within wide limits, as was shown in G. S. Callendar's interesting article in the issue of this Magazine for March 1939, and he considers that this may have been one of the causes of climatic changes.

On the whole these purely terrestrial factors appear to give an adequate explanation of the slow changes of climate from one geological epoch to another. They do not account for the more rapid oscillations which can sometimes be recognised within the limits of a single period. Thus while the Quaternary was on the whole cold, the ice sheets and glaciers fluctuated greatly in magnitude and for at least one long interval disappeared almost completely. These fluctuations are best known from the Alps, where they are the subject of a classic work by Penck and Brückner(4). These authors recognised four glaciations, Gunz, Mindel, Riss and Wurm, the latter ending about 20,000 years ago. The Gunz-Mindel and Riss-Wurm interglacial periods were relatively short, but the Mindel-Riss lasted for about 240,000 years. Similar advances and retreats have been recognised in other parts of the world, and they have

been the subject of many theories. Sir George Simpson(5) attributes them to cyclic changes of solar radiation, the balance between accumulation and ablation of snow being so delicately adjusted that glaciation occurs at intermediate stages. At the maxima of radiation precipitation is heavy but temperature is too high for ice sheets to exist, while at the minima, temperature is low but snowfall is insufficient. This theory is supported by the evidence for great pluvial periods in equatorial regions. Milankovitch(6) relates the advances and retreats of the glaciers to variations in the obliquity of the ecliptic and the eccentricity of the earth's orbit, combined with the precession of the equinoxes. With certain assumptions the changes of summer radiation resulting from these astronomical variables do resemble the advances and retreats of the ice. In earlier geological periods certain rocks which are made up of annual layers of sediment seem to show the effect of the precession of the equinoxes very clearly(7). The same rocks also show the eleven-year sunspot cycle and possibly other solar periodicities but nothing of the length required by Simpson's theory.

There was one remarkable occurrence which seems to violate all orthodox meteorology. The Carboniferous Period takes its name from the great beds of coal which characterise it in the northern hemisphere, and which bear the aspect of a rich tropical vegetation. Yet in low southern latitudes in Australia, Africa and America and even across the equator in India, great ice sheets co-existed with the northern forests. It is hard to escape from the inference that in the Carboniferous the equator did traverse Europe and North America while the southern continents were grouped around the South Pole. A mere shifting of the earth's axis will not suffice, the continents must be crowded together, beginning by fitting South America into the bight of Africa. That is the theory of the late A. Wegener (8, 9) who developed it with great ingenuity, moving his continents like pieces on a chess-board to cover all the major climatic changes which earlier in this article were associated with

geographical conditions. If Wegener is right, other theories are redundant, but there are many difficulties, which are discussed at length of H. Jeffreys(10).

With so many conflicting opinions it may be asked if the climatic changes of the last few thousand years in northern Europe, for which all the factors are known with some exactitude, do not give a casting vote. The answer is, unfortunately, no. After the retreat of the ice there followed first a period of continental climate, with hot summers and cold winters, then a more equable period of warmth, the "Climatic Optimum", and finally a return to existing conditions. The continental period fits the increased obliquity of the ecliptic about 8000 B.C., while the Climatic Optimum is claimed by Simpson in support of his solar theory but can also be interpreted as the result of an enlarged Baltic, open to the warm waters of the North Atlantic. The rise of temperature in recent years is, according to Callendar, the result of human activity in adding millions of tons of carbon-dioxide to the air. Finally, determinations of longitude have so far failed to decide whether or not the continents are drifting. The problem of climatic changes is still unsolved.

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FOREST FIRES IN AMERICA AND THEIR EFFECT ON THE WEATHER

By A. H. Gordon, M.S. (Pasadena)

The North American continent is perhaps unique among the regions of the globe which are inhabited by white peoples in its ability to produce such a variety of destructive natural phenomena, nearly all of which are either an instantaneous or consequent result of a meteorological effect. Raging West Indian hurricanes,

Fig. 1. Sketch of Western North America.

whirling tornadoes, extensive floods, prolonged droughts, intense heat and cold waves, blinding blizzards and searing dust storms are all too frequent in demonstrating how ably the weather can destroy man's works and disrupt his way of living. Finally, but by no means the least of this formidable array, there is the huge forest

fire, to the occurrence of which a great deal of study has been given in order that precautions may be taken and outbreaks averted or controlled in their early stages. Although the forest fire is not an atmospheric phenomenon in itself, its occurrence is very largely dependent on existing meteorological conditions in relation to the general climatology of the region. In addition the fire exerts its own rather limited influence on local weather.

Regions in which forest fires occur with any degree of regular frequency are confined mainly to the western and Rocky Mountain areas of the United States. At times of unusual dryness they also occur in the southern portion of the Canadian provinces of Alberta and British Columbia. A great deal of the western half of the United States, especially that part north of an approximate parallel 40° North Latitude, is covered with vast forests of fir, pine and redwood. South of this parallel the timber is mainly found in the more mountainous type of country. In the hilly districts of southern California there is a great deal of brush; in the dry season this makes excellent fuel upon which a conflagration may feed once it has been started by a carelessly dropped match or piece of lighted tobacco ash. Real forest fires usually do not break out unless the season has been a particularly dry one. In some seasons there may be none at all while in others they burn in hundreds throughout a vast area, ravaging thousands of square miles of land, destroying towns and villages, and driving all kinds of wild animal life before them. Brush fires are kindled with much greater ease and blaze furiously although they cover less ground and burn out more rapidly. As a rule, however, they present the greatest danger to human life and property because of the great speed with which the flames leap from bush to bush when blown by a strong and very dry wind. The unfortunate occupants of an exclusive mountain resort hotel or elaborately constructed house or cabin which may happen to be in the path of the oncoming flames frequently have no time in which to save their belongings and can only barely save their

lives. Dangerous indeed is the life of the fire fighter. In the bad Griffith Park fire near Hollywood a few years ago a sudden shift of wind caused a small backfire to creep round to the rear of a score or more of men who were valiantly stemming the main outbreak. Trapped in a narrow canyon by a roaring inferno they all perished.

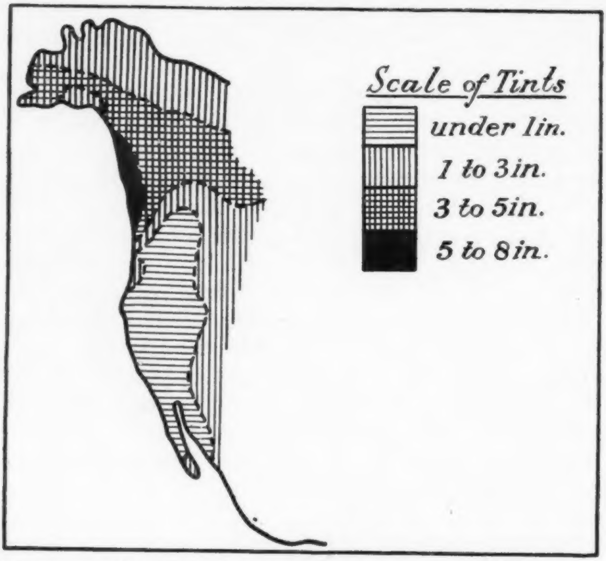

FIG. 2. COMBINED RAINFALL, JULY AND AUGUST, IN WESTERN NORTH AMERICA.

The underlying conditions which are favourable for the kindling and growth of fires in the huge timber forests are an unusually large deficit of rainfall extending back over a considerable period, coupled with high temperatures and very low desert-like humidities. The rainfall régime in those regions which possess the greatest frequency of bad type fires is distinctly seasonal in character and distribution. Along the narrow strip of country between the Pacific coastline and the coast ranges the mean annual rainfall north of the Oregon California border amounts to a total of over one hundred inches. Southwards this value diminishes rapidly to

fifty inches near Cape Mendocino and then more slowly to twenty five inches at San Francisco, and to ten inches along the Mexican frontier. Of these annual totals the average combined amount for July and August is approximately two inches north of the Oregon California border, a quarter of an inch near Cape Mendocino, and nil at San Francisco. At this time of the year San Diego comes under the influence of tropical type thunderstorm rain to the extent of about a quarter of an inch. North of the 36th parallel the wider belt of valley country lying between the coast and the High Sierra ranges possesses a considerably smaller mean annual total of rainfall than the coastal strip but the monthly distribution curve is very similar. South of the 36th parallel the territory to the east of the coast ranges is mainly desert and has a very scanty rainfall. The Rocky Mountain region to the east of the High Sierras possesses a different type of rainfall regime altogether with a moderate fall of thunderstorm character in summer. However, the high temperatures and low humidities of this region are sufficient to create quite favourable conditions for the occurrence of fires.

In the Pacific northwest the forest fire hazard seldom becomes dangerous until the latter part of August. The worst period is usually in early September although it may persist until October if the early autumn rains are delayed. On days when the wind is from the interior of the continent and thus extremely dry the risk of fires is greatly enhanced and special precautions are taken by the forest rangers. It is believed that fires result from natural causes in only a very small proportion of cases and that the majority occur purely through carelessness on the part of motorists and campers. Very strict regulations have had to be issued and enforced. In the danger areas smoking and camping are only permitted in definite supervised open spaces, and if the hazard becomes particularly bad these areas are completely closed to the public. A huge organized fire prevention campaign is launched each year by the district authorities. In the cinema, in the papers, on the roads, in trams,

trains and buses every individual is kept aware continually of the part that he must play in safeguarding the nation's already depleted wooded preserves; he is warned that neglect and carelessness in this respect can be a penal offence. It is fully realized that prevention is the best cure. Once an outbreak has started it rapidly spreads beyond all control and in bad years outbreaks occur in such numbers that available resources of men and material can do little to curb them.

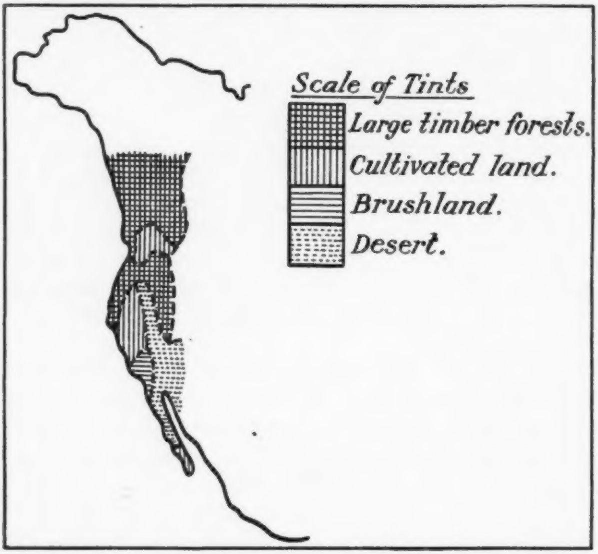

FIG. 3. TYPES OF VEGETATION IN REGIONS WHERE FOREST FIRES OCCUR.

Naturally enough the main effect of the forest fire on local weather is the deterioration of visibility. When a large area of forest land is burning a dark yellow pall of smoke covers the sky for miles around giving it an appearance very like that imparted by a November fog in London, but in place of the raw feeling of a cold and damp atmosphere there is the stuffy and enclosed sensation of a warm and very dry atmosphere. The pressure distribution which is most favourable for the

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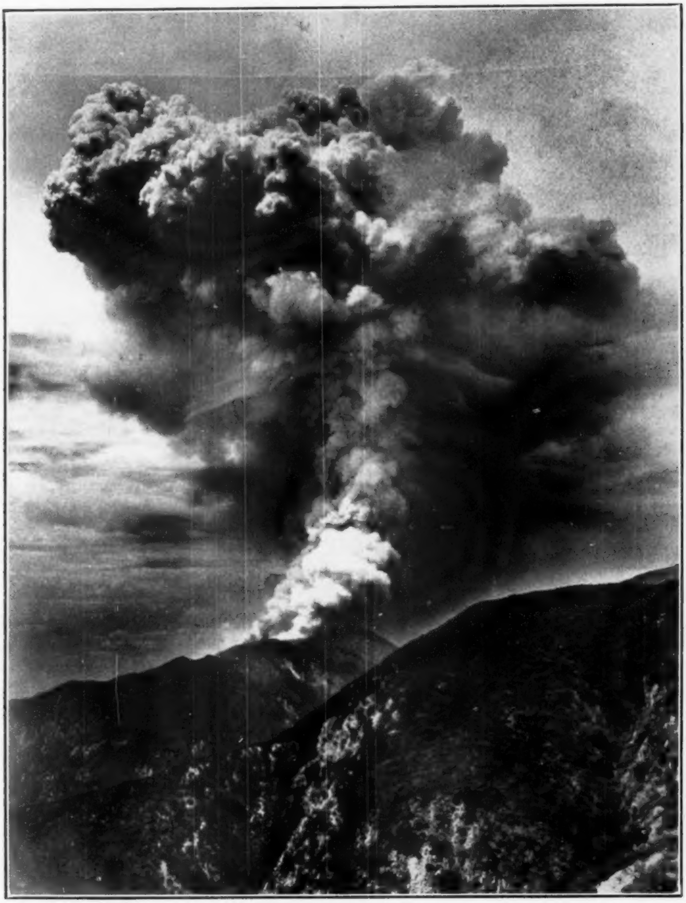

Photographer: O. H. Lawrence.

CUMULUS CLOUD FORMED BY CONVECTION OVER FIRE ON SISTER ELSIE PEAK, CALIFORNIA, SEPTEMBER 13TH, 1913.

(Reproduced from "Physics of the Air," by W. J. Humphreys, by permission of the United States Weather Bureau and of the publishers.)

development of forest fires is the presence of a subsiding anticyclone centred over the Rocky Mountain region; thus the inversion aloft forces the smoke pall to remain in the surface layers of air. At times, under the influence of several evenly distributed fires thousands of square miles become affected by the smoke haze. The visibility falls to an average value of 1,000 to 2,000 yards over the region, decreasing to almost nil to the lee of the fire. Aviation is hindered and many phases of industry are handicapped. Many roads are closed to all but those who are engaged in combating the flames. Extensive inhabited areas become isolated and wholesale evacuations of towns are ordered. Ashes and cinders fall continuously and cover everything with a coat of dust and dirt. In recent years the city of Portland, Oregon, has suffered particularly from this last-mentioned inconvenience. When such conditions exist throughout a large area very little can be done to remedy the situation. Even though the actual flames may be extinguished, red hot glowing embers will last for days, and the most exhaustive vigilance must be kept to prevent sparks from catching alight the nearby undergrowth until a break in the dry weather spell eases the tinder-dry state of the vegetation. In the autumn, especially along the coastal plains, the rains may begin at any time and greatly reduce or entirely eliminate the existing hazard, but if it should be midsummer the position is a most unfortunate one. Thunder showers in the interior are a great help in dampening the ground and increasing the humidities, but they are rather infrequent in occurrence and as a rule extremely local in character. Thunder and lightning often develop with little or no fall of rain and in cases such as these the discharge to earth is quite an important agent in starting a fire in the first place. Moreover, a fire often has been observed to create its own convective cloud. If there is a tendency towards instability, trigger action caused by the tremendous local heating effect may be responsible for the occurrence of a shower or thunderstorm. Thus it is quite conceivable that a forest fire may be the initial cause in putting itself out!

In contrast to the slow burning timber fires of the north, the brush fires of the southland coastal regions are of relatively short duration and create little smoke nuisance. The worst type of fire usually occurs in November or December in a year when the winter rains are late in arriving, and five or six months of high temperatures and almost absolute drought have extracted almost every available drop of moisture from plant growth. Conditions in summer are not so favourable for the starting of fires also because the humidities are higher at that season of the year. The Pacific anticyclone creates a prevailing northwest wind along the coastal plain and the consequent welling up of cold sea water forms a permanent low level inversion. The surface layer of air offshore is thus a cool foggy one which drifts inland becoming warmer and drier as it does so. In the early hours of the morning the low cloud layer occasionally extends fifty or sixty miles inland, but it dissipates rapidly under the sun's rays.

In November the mean pressure distribution has changed entirely. The oceanic " high " has moved far southwards and the Aleutian " low " has intensified greatly. A Polar type anticyclone has developed over the western interior plateau. At times this Polar Basin " high ", as it is called, builds up very rapidly and creates a steep gradient between the plateau and the coastal plain. The cold dry air is forced down the mountain slopes and attains gale force upon reaching the valleys. This wind is known as the Santa Ana and it frequently does a great deal of damage. Its worst effect is not found in structural injury, but in the loss of crops caused by the searing heat and great dryness of the dust-laden air. It has a most uncomfortable and depressing effect upon human beings and in this respect is very similar to the Scirocco of the Mediterranean. The abrupt mountain descent has been known to give midnight temperatures of over 80° F. in midwinter. This amounts to an adiabatic increase of temperature of some 40° to 50° F. The relative humidity in the Santa Ana is usually between 5 per cent. and 15 per cent. A very

recent example of most unusual adiabatic heating occurred during the second week of December, 1938, when all temperature records for the month in Los Angeles were broken. A five day spell brought a mean maximum of 88° F. and the mercury on one day touched 92° F!

Under this type of weather a fire can almost start by itself! The only way to check a bad conflagration in these conditions once it has become out of control is to attempt to confine it to a limited space by means of making, and carefully guarding, wide and extensive fire breaks. To use water, of which there is probably none within miles anyway, is as unpractical as to try and put the sun out. The heat is intense and is felt for miles around. At night the fire is a stupendous sight; it can be seen for 50 or 60 miles and at times possesses a 20 or 30 mile front itself. It appears to resemble some titanic firework display and but for the constant reminder that it is really a terrible catastrophe it is a most thrilling sight to watch. Crowds of cars turn out with the purpose of approaching the flames as near as possible; the traffic problem alone is a serious matter with which to contend. The dangerous areas, however, are rapidly closed to the public. The immediate vicinity of the fire is particularly unsafe because of the violent turbulent currents generated by the huge lapse rate. Excellent examples of tornadoes can be seen twisting their way over the burning brush, sucking up flaming embers and casting them away.

One of the most essential phases of the work of the U.S. Weather Bureau is the information and advice given out to the forest rangers as to the advisability of opening or closing to the public various wooded natural preserves. When weather conditions become unusually warm and dry, a detailed section of its daily forecasts is devoted to the issuance of a fire hazard warning. It is just one more way in which the science of meteorology as a whole, and the art of weather forecasting in particular, are becoming of invaluable aid in a practical way to the progress of social life and civilization in our present-day world.

PROFESSOR GUSTAV HELLMANN

3rd July, 1854–*12th February,* 1939.

The death of Professor Gustav Hellmann in his 85th year closed a long life of devotion to the science of meteorology in general, and to the study of rainfall distribution in particular. Unlike most of the leaders in nineteenth century meteorology, Gustav Hellmann was a meteorologist from the first, resembling in this respect his English friend George James Symons. After taking his degree at the University of Göttingen he obtained an appointment in the Prussian meteorological service and worked his way steadily upwards, until on the death of Professor von Bezold, in 1907, he succeeded as Director of the Prussian Meteorological Institute. At the same time he became Professor of Meteorology in the University of Berlin. He was a member of the International Meteorological Committee from 1903 until the War put a stop for a time to its activities, and he acted as Secretary for seven years. During that time he collaborated with Professor Hildebrandsson of Upsala in compiling the important International Meteorological Codex, and at the meetings of the Committee his remarkable knowledge of languages enabled him to maintain easy communication with members from every country.

The work of the Prussian Meteorological Institute differed from that of the British Meteorological Office in being confined to the equipment and supervision of observing stations and to the climatological treatment of the results. The department dealing with rainfall was that in which he took most interest and pleasure and he was in close correspondence with Symons on the problems involved in deciding on the best form of raingauge and on the distribution of stations. Each took many hints from the other although they did not agree as to a uniform system applicable to both countries. Hellmann made experiments which led him to adopt the plan of placing the raingauge on a post with its rim one metre above the ground, while Symons saw good

reasons for making one foot the standard height in the British Isles. Hellmann, with the command of State funds and a rigid system of inspection, had satisfaction in a fixed number of observing stations set out singly at equal distances, while Symons, who had to depend on voluntary observers, strove to increase the number of gauges even in crowded areas, and in thin areas preferred not single gauges, but groups of several (a mile or so apart) the intervals between groups being as uniform as possible. I have had many discussions with Professor Hellmann on the relative advantages and drawbacks of the two systems.

Professor Hellmann recognized that climatology depended as much on geography as on meteorology and it was natural that he should have served for many years as President of the Berlin Geographical Society, and have been an Honorary Member both of the Royal Meteorological and the Royal Geographical Societies in London.

Hellmann's most important published work on rainfall was the fine series of average rainfall maps of the provinces of North Germany, with the accompanying memoir on the rainfall of the river basins concerned, entitled " Die Niederschläge in den Norddeutschen Stromgebieten ", published in 1906. Another very valuable research, in which he was assisted by Dr. G. v. Elsner, was a consequence of the serious flooding in the German plains in 1903, which was also the wettest year in this country. By means of close mapping of the rainfall for individual days in comparison with maps of barometric pressure and temperature, he investigated the causes of the floods of the Oder valley and deduced a method of flood warnings sufficiently in advance of the rise of the water-level to allow precautions to be taken by persons in danger. A large volume entitled " Meteorologisches Untersuchungen über die Sommerhochwasser der Oder ", and an Atlas of charts was published in 1911.

Professor Hellmann represented German meteorologists at the Jubilee of the Royal Meteorological

Society in 1900 and in 1908 he delighted the Society with his lecture on The Dawn of Meteorology, for he had made a special study of the early history of the science of the air which he pursued as a hobby closely related to his professional work but different enough to serve as relaxation.

Professor Hellmann was a pleasant companion with wide sympathies and courteous manners. The hospitality he and his charming wife dispensed in their Berlin flat remains one of my pleasantest memories of that city. Nor was he less agreeable as a guest when staying in this country with the friends he liked.

HUGH ROBERT MILL.

LIGHT SOURCES FOR PILOT BALLOONS

The following points of interest are taken from an article " On Pilot Balloons and Sources of Light for High Altitude Upper-wind Observations," by W. H. Wenstrom in the *Monthly Weather Review,* September, 1937, p. 326.

Experiments with 16-in. balloons (weight 3½ oz.) inflated to a free lift of 40 oz. showed that, if a weight up to 10 oz. was hung by a string 50 ft. below the balloon the rate of ascent not only was not reduced, but became more uniform with height. With a 5-oz. weight the rate was actually increased, probably owing to a reduction of oscillation and to the improved stream-line shape of the balloon.

As regards light sources, it was found that a 2·3-volt 0·25-amp electric bulb with two 1·5-volt dry cells gave about the same range as a single candle in a paper lantern, both being visible at distances of 3 to 6 miles. These were used with 6-in. balloons. This does not accord with British experience, where it has been found that a considerably more powerful electric bulb is necessary to give results equal to those given by the candle. For 16-in. balloons various sources of light were tried, viz. candles, electric lamps, acetylene and pyrotechnic

flares. A paper lantern with four candles was found to be visible two or three times as far as the single candle, i.e. 8 to 15 miles. The candles were fixed in holes in a piece of plywood.

Six candles gave slightly better performance than four, but an 8-candle lantern caught fire too easily and was not successful. There seems, however, no reason why any number of candles should not be used provided the lantern were big enough, but the number is limited by the burning time required and the weight allowable.

Another arrangement consisted of four short and four long candles. The long candles were lit first, the short ones lighting from them after about 20 minutes. This was only tested on the ground, but it was considered promising. An 8-volt electric bulb with six 1·5-volt dry cells gave a good light at first, but the efficiency fell off quickly and the range was rather less than that of the 4-candle lantern. Electric lamps suffer from the disadvantages of high cost, weight, diminishing candle-power and danger to objects on the ground when they fall.

An acetylene burner gave a brilliant light, but tended to blow out when the rate of ascent was as great as 1,200 ft./min. This was, however, considered to be worth further experiment; it has the advantage of cheapness and lightness. The acetylene was contained in a small balloon attached to the main balloon. The best light of all was given by a red pyrotechnic flare. Starting from small standard flares used by the United States railways, various modifications were made with a view to prolonging the burning time and securing that the candle-power should increase as the flare burned away. Considerable progress was made, but complete reliability was not attained. The flares tended to go out at about 10,000 ft., possibly through deficiency of oxygen. A safety balloon was necessary to prevent the burning flare from dropping to the ground if the main balloon burst prematurely.

D. N. HARRISON.

LETTERS TO THE EDITOR

A Fine Sun-pillar, March 8th, 1939

On March 8th, 1939, at Gausdal* in the Gudbrandsdal district of Central Norway I watched the sun go down in an almost cloudless sky. The moment the orb itself had disappeared, a delicate, golden pillar of considerable brightness and glitter appeared in the sky where the sun had gone down. Its width was the same as the sun's diameter, and it reached some 3° or 4° above the skyline to where it was lost in the last bright remnants of degenerating cumulus.

Mr. G. A. Clarke of Aberdeen has shown me a photograph of such a sun-pillar, with the sun itself in view shining through cirrostratus cloud. On this occasion there was no cirrostratus to be seen; but the sky was a very delicate blue, and there was no redness about the sunset. The cloud must have existed in a diffuse, nebular form: which explains the fact that the pillar certainly did not reach more than 5° above the skyline and only came into view once the sun itself was hidden. The sun had set behind a rugged mountain ridge and by going a few hundred yards further over the hill one could bring it into view again. Immediately the pillar of light vanished, but reappeared once the sun was hidden again.

I cannot say how long the phenomenon lasted altogether, as it was unfortunately obscured after five or six minutes by the one remaining patch of low cloud. The time was about 16h. 45m. G.M.T., and the general weather conditions were outstandingly clear with a northerly wind current and a light frost over the snow-covered landscape.

H. H. LAMB.

Meteorological Office, Donibristle, Fife.
March 20th, 1939.

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* Gausdal is 61.3° N., 10° E.

A Lunar Halo Observed on February 28th, 1939

On Tuesday February 28th, 1939, at 19h. G.M.T., there was a lunar halo in the form of a white ring of 22°. This lasted for about half an hour and then the cirrus cloud dispersed. At 20h. the sky was clear except for drifting patches of strato-cumulus at about 5,000 feet. On observing that one of these patches was about to pass in front of the moon, I decided to watch its passage across it.

Firstly a normal corona was thrown on the edges of the cloud. As the cloud passed, the corona became denser in colour, and finally when the thick portion of the cloud was passing, I observed that two coronæ were visible, one inside the other. The inner one had a diameter about three times that of the moon, and the outer one about five times that of the moon. The space between the rings was coloured pale blue nearest the inner corona, and pale green towards the outer one. The phenomenon was visible for about five minutes, and as the sky was soon clouded over, it was not observed to occur again.

D. C. Mason.

Meteorological Office, South Farnborough, Hants.
March 3rd, 1939.

NOTES AND NEWS

Retirement of Dr. F. J. W. Whipple.

Dr. F. J. W. Whipple retired on March 31st at the age of 63. He was educated at Merchant Taylors School and Trinity College, Cambridge, where he took his B.A. in 1897. In 1899 he returned to Merchant Taylors School as Assistant Master. In 1901 he received the degree of M.A. and in 1928 that of Sc.D.

In 1912 he joined the staff of the Meteorological Office as Superintendent of Instruments, subsequently taking charge in 1916 of the Statistics Division, which dealt with all climatological work, and in 1923, after the death of Mr. Carle Salter, of the British Rainfall Organization. He was promoted to Assistant Director

in 1925 when he became Superintendent of Kew Observatory, a post which he held until his retirement. He was joint editor with Mr. Salter of the *Meteorological Magazine* from 1920 to 1923, and subsequently sole editor until 1925. He has also taken a large part in the work of the Royal Meteorological Society, serving as President in 1936 and 1937.

Dr. Whipple's family has been closely associated with Kew Observatory since 1854, when his grandfather, Robert Beckley, became an assistant, at first the only one. His father, G. M. Whipple, went to the Observatory in 1858 and was Superintendent from 1876 to 1883 and his brother, R. S. Whipple, who was until recently Managing Director of the Cambridge Instrument Company, was there from 1886 to 1896. It was most appropriate that Dr. F. J. W. Whipple, two of whose christian names, John and Welsh, were given in memory of the first Superintendent under whom his father and grandfather had served, should take charge of the Observatory in his turn.

Dr. Whipple's scientific interests are very wide, extending beyond meteorology over the whole domain of geophysics and he has written purely mathematical papers, mostly on the theory of series. Much of his work is connected with air waves and abnormal acoustic phenomena in the atmosphere, and in 1935 he delivered the Symons Memorial Lecture on the subject of " The propagation of sound to great distances ". He is keenly interested in seismology, meteorological optics, meteors, atmospheric electricity, hygrometry and upper air investigation (he designed the pilot balloon slide-rule now in general use), and he has written, and will we hope continue to write, on almost every aspect of geophysics.

Dr. A. H. R. Goldie.

On April 1st, Dr. A. H. R. Goldie became an Assistant Director of the Meteorological Office. Dr. Goldie was born in Linlithgowshire but his early life was spent at Glenisla, Angus, a few miles from the early home of

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Photographer : A. Swan Watson.

A. H. R. GOLDIE, D.Sc.

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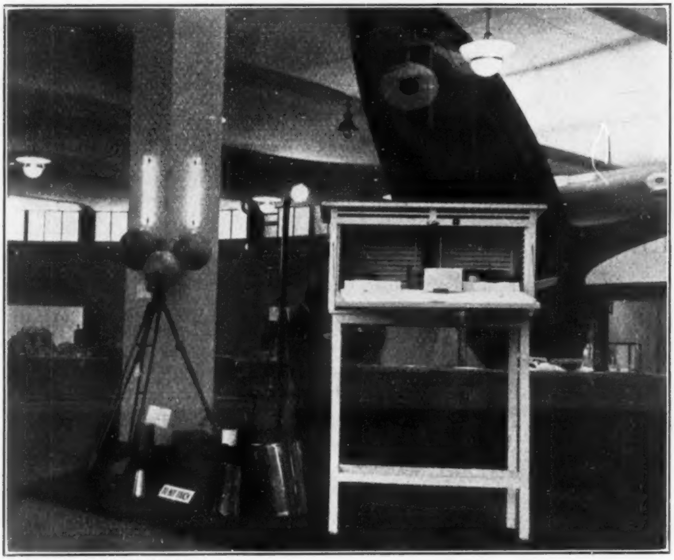
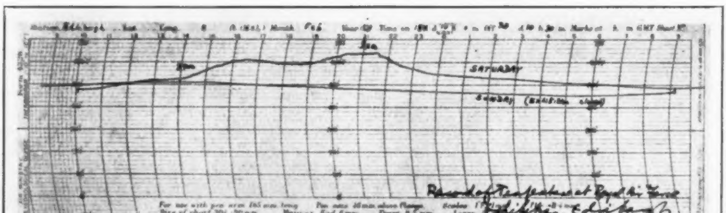


Photographer: H. E. Carter.

METEOROLOGICAL OFFICE EXHIBIT AT R.A.F. AIRCRAFT EXHIBITION, FEBRUARY, 1939.



RECORD OF TEMPERATURE AT THE EXHIBITION, FEBRUARY 18th, 10H. TO FEBRUARY 20TH, 10H. 30M.

Dr. C. Chree. Dr. Goldie was educated at Harris Academy, Dundee, St. Andrew's University, where he received the degree of M.A. with first class honours in Mathematics and Natural Philosophy, and St. John's College, Cambridge, where in 1913 he was a Wrangler in Part II of the Mathematical Tripos. Dr. Goldie entered the Meteorological Office in 1913 as a Professional Assistant, serving in the Forecast Division, Falmouth Observatory and Farnborough and later as Senior Assistant at Eskdalemuir Observatory. In June, 1915 he obtained a commission in the Meteorological Section, R.E., he served in France and Italy and was twice mentioned in Despatches. After the war he became Superintendent of the Aviation Services Division until 1924, when he took charge of the Meteorological Office at Edinburgh. He was awarded the degree of D.Sc. at St. Andrew's in 1936.

Dr. Goldie's interests have been chiefly in the direction of atmospheric electricity and terrestrial magnetism—since 1936 he has been Secretary of the International Association for those subjects in the International Union for Geodesy and Geophysics—wind structure and the dynamics of depressions. His Geophysical Memoirs on the latter subject are well known as also is his revision of Abercromby's famous book on " Weather ".

Meteorology at the Royal Air Force Exhibition in Edinburgh.

A Royal Air Force Aircraft Exhibition was opened in the Waverley Market, Edinburgh, on February 14th, 1939, by the Secretary of State for Air, Sir Kingsley Wood, in the presence of a distinguished company which included the Lord Provost of Edinburgh, the Secretary of State for Scotland and senior members of the Services. The exhibition included a replica of a meteorological observing station as provided at R.A.F. and civil aerodromes with a Stevenson screen containing thermometers, a recording thermograph and a hygrograph. A Dines' tilting bucket raingauge, standard 5-inch raingauge, Campbell-Stokes sunshine recorder, Besson nephoscope, Dines' meteorograph and the latest

type of pilot balloon theodolite were attractively arranged on a square of imitation turf. The new theodolite fitted with night illuminating gear attracted particular attention. In addition there were displayed a series of synoptic weather charts and diagrams illustrating official meteorological wireless services. Members of the staff of the Meteorological Office were in attendance and explained the exhibit to a constant stream of inquirers.

The exhibition remained open for 11 days during which nearly 180,000 people visited it. The mornings were reserved for those interested in the manufacture of aircraft and parts thereof. The daily influx of the general public commenced at 2 p.m., and continued until the tea hour when numbers remained almost stationary, then rose to its peak in the evenings; the effect of this was reflected exactly in the records of the thermograph. These show a characteristic diurnal variation with the principal maximum about 9 p.m. and a rapid fall after 10 p.m. when the doors of the exhibition were closed. The daily range is of the order of 15 degrees, except on the Sundays when the exhibition was closed and the traces are smooth with a range of only 3 or 4 degrees.

H. E. C.

Royal Meteorological Society.

The usual monthly meeting of the Society was held on Wednesday, the 15th instant, in the Society's rooms at 49, Cromwell Road, South Kensington. Dr. B. A. Keen, F.R.S., President, was in the Chair.

The following papers were read and discussed:—

The influence of the Dead Sea on the climate of its neighbourhood.—By D. Ashbel.

The topography of the Dead Sea is described and it is shown how the difference in depth and area betwen the northern and southern basins is reflected in the thermal relations with the surrounding land and in variations of the sea breeze, resulting in a morning maximum and mid-day minimum temperature. An account is given of the effect of the sea breeze from the Mediterranean, which reaches the Jordan valley in the afternoon as a hot, dry wind and produces a second maximum temperature. Examples are quoted of the extent in different directions of the influence of the sea breeze from the Dead Sea; and its effect on khamseen days, when the afternoon

temperature maximum disappears, is discussed. Data are given in tables of wind direction and velocity, with autographic records of temperature and humidity, and brief particulars of the amount of precipitation are included.

Local climate and the growth of trees, with special reference to frost.—By W. R. Day, M.A., B.Sc.

The type of forest is largely determined by the general climate, but local climatic conditions exercise considerable influence. The natural forest in this country is composed of species, some of which are relatively hardy to frost, whereas others are, in comparison, easily injured by it. The latter species usually form the final woodland, and their successful growth is made possible by the development of favourable conditions of climate and soil within woodland formed first of all by hardy species. Examples are given to illustrate the effect of overhead and side shelter on the temperature of the air over the ground. The influence of topography on frost is also illustrated and discussed. The effect of accessory factors, such as soil fertility, local warm or cold situations, and the general suitability of the exotic species to the climate to which they are introduced are also shortly discussed in relation to the occurrence of frost injury.

High latitude ozone measurements.—By R. A. Hamilton, M.A.

Observations were made at North-East Land to determine the amount of ozone in the upper atmosphere by measuring the absorption of the ultra-violet light in the spectrum of the Pole star. A quartz spectrograph was used and the spectra were examined by a photometer. The densities of the spectra for wavelength 3290 and 3092A were compared with equal densities on an image on the plate of a source of light whose intensity varied along the image according to a known law. The constants were determined by carrying out a similar experiment at Oxford at night when the amount of ozone on the previous and following days had been measured by the standard method. Trouble was caused by the fogging of the plates caused by auroral light, but this was corrected for by a statistical method. The mean error of each determination was of the order of 30×10^{-3} cm., but the day-to-day fluctuation was found to be far greater than this and than the fluctuation observed in lower latitudes. There was no apparent connexion between the amount of aurorae and the amount of ozone. The results show that the autumn fall in the amount of ozone, observed at all latitudes, is continued through the winter and is followed by a sudden rise in spring.

Easter Weather in 1284.

In the present year Easter Day falls upon April 9th. It also fell upon that day in 1284 and John Everisden, monk of St. Edmund's Abbey, tells us of a notable thunderstorm which happened at Bury St. Edmund's on that occasion. He writes: On Easter Day, which fell

on the fifth of the Ides of April, about the first hour of the day, there was at St. Edmund's such a sudden and unexpected flash of lightning, and such loud and continued claps of thunder, that those who heard them could scarcely hold their footing. And although the storm was so violent in that place, it did no harm in the country, or but very little. We have heard that the same storm occurred in parts beyond the seas, the same day and hour.

This storm was certainly experienced in Oxfordshire also. The writer of the contemporary Annals of Osney Abbey records: On Easter Day, which fell this year on the fifth of the Ides of April, it being a leap year, at about sunrise in the morning, such a thickness of the air obscured the sky, that the morning, which should have grown light unto the day, was like the darkness seen in the night time, and suddenly a horrible storm began to burst forth; first hail and rain, and then a heavy snow was loosed, which covered the whole ground; third, such horrid lightnings and concussions of thunder, that the souls of the beholders and the hearers likewise were brought to amazement . . . .

In 1413, April 9th was Passion Sunday and also the Coronation Day of Henry V. The weather was very stormy and a number of contemporary writers comment on this. The lawyer, Adam of Usk, who was present at the ceremony, writes: On the same day an exceeding fierce and unwonted storm fell upon the hill country of the realm, and smothered men and beasts and homesteads, and drowned out the valleys and the marshes in marvelous wise, with losses and perils to men beyond measure.

Thomas Walsingham, scriptoriarus and precentor of St. Albans Abbey, adds: On which day there was a great tempest of snow, everyone wondering at the sharpness of the weather.

C. E. Britton.

New climatological stations.

Mr. R. G. Sandeman of Crickhowell (Dan-y-Parc), who has forwarded rainfall observations to the Office since

1929 has maintained a climatological station for some years. Arrangements have now been made for a summary of the records to be included in the *Monthly Weather Report* to which they form a useful addition.

A well-equipped station, with a Dines tube anenograph has been set up by the Borough Council at Southgate (Oakwood Park).

Professor D. Brunt.

We have pleasure in announcing that Professor David Brunt has been elected to the Fellowship of the Royal Society.

Mr. P. A. Sheppard.

Mr. P. A. Sheppard, B.Sc., has been appointed to the University Recordership in Meteorology tenable at the Imperial College of Science and Technology.

REVIEW

Normal monthly percentage frequencies of surface and upper winds up to 3 km. at Allahabad, Begumpet, Delhi, Sambalpur, Sandoway, Silchar and Victoria Point. Simla, Ind. Met. Dept. Sc. Notes VII, 72, 1937.

The India Meteorological Department have already published in Scientific Note No. 17, tables of monthly percentage frequencies of upper winds for heights up to 3 km. at 32 stations in or near India. The publication under review contains similar tables for seven more stations (two in Burma) although the data are arranged in a slightly different form. The extension of these tables up to 10 km. has already been completed for 34 stations in Scientific Note No. 66 and one may confidently expect the India Meteorological Department to publish in the near future the data up to 10 km. for the remaining stations.

A word of caution is perhaps desirable regarding the use of these tables. For a number of reasons pilot-balloon ascents may be terminated after a comparatively short interval. If the early termination of ascents is mainly associated with certain meteorological conditions, the summaries will be biassed against those conditions. For example, the early loss of the balloon in low cloud may be more frequent with certain winds than with others. Again, it is not practicable to make a pilot balloon ascent when it is raining; or high winds may carry the balloon out of the field of view before it reaches an appreciable height. Rain, low cloud and rather high winds are all very frequent during the monsoon season. Hence in this period the summaries must be biassed in favour of clear days at the greater heights.

It is significant that, during the monsoon months the ratio of the number of observations at 3 kms. to the number of observations at or near the surface, falls to a third or an even smaller fraction. The ratio is noticeably higher during the non-rainy months. Perhaps, with the upper air temperature data which they have at their disposal, the India Meteorological Department may be able, by means of computation, to remedy to some degree the inevitable deficiency in summaries based on pilot-balloon observations alone?

R. G. VERYARD.

Sunshine, March, 1939.

The distribution of bright sunshine for the month was as follows:—

	Total hrs.	Diff. from average hrs.		Total hrs.	Diff. from average hrs.
Stornoway ..	124	+15	Chester ..	89	−25
Aberdeen ..	95	−14	Ross-on-Wye	80	−36
Dublin ..	90	−25	Falmouth ..	126	−10
Birr Castle ..	93	−18	Gorleston ..	101	−27
Valentia ..	100	−16	Kew.. ..	93	−15

Kew temperature, mean, 43·7° F.: diff. from average, −0·2° F.

Daily Readings at Kew Observatory, March 1939

Date.	Pressure, M.S.L. 13h.	Wind, Dir. 13h.	Force	Temp. Min.	Temp. Max.	Rel. Hum. 13h.	Rain.	Sun.	Remarks.
	mb.			°F.	°F.	%	in.	hrs.	
1	1007·7	WSW	3	39	49	56	trace	3·4	pr_0 6h.
2	14·2	S	4	45	57	66	—	0·3	
3	14·1	S	3	42	58	66	—	6·6	
4	10·5	S	3	49	53	80	0·06	0·7	r_0–r 14h–16h.
5	11·7	SW	5	46	55	47	0·06	5·3	r_0–r 2h–4h.
6	18·3	SW	4	45	54	58	—	3·2	
7	22·0	NW	4	41	49	50	—	6·7	
8	17·5	WSW	5	41	52	55	0·14	0·8	q RH 19h, r_0 19h–
9	21·5	N	3	37	49	56	—	5·1	[21h.
10	28·6	NE	2	33	49	54	—	7·8	f 22h–24h. [–24h.
11	24·6	S	2	29	45	90	0·17	0·0	f–F 0h–12h, r–r_0 19h
12	32·9	NNE	3	41	45	66	0·02	0·4	r_0 0h–2h & 6h–8h.
13	37·0	NW	3	32	49	49	—	4·1	
14	29·6	NW	3	44	53	73	—	0·0	
15	29·7	NNW	4	44	46	58	trace	0·7	pr_0 4h & 5h.
16	21·9	WNW	3	39	51	66	0·07	0·3	ir_0 5h–7h & 15h–18h.
17	16·2	NNE	5	40	46	72	0·05	1·4	pr_0h_0 12h, 15h & 16h.
18	26·4	NNE	4	33	40	52	trace	1·3	pr_0 19h.
19	18·9	NNE	4	37	45	66	0·04	0·1	r_0 1h–5h & 6h–7h.
20	17·4	WNW	3	38	48	62	trace	0·3	pr_0 18h.
21	15·1	NW	5	41	49	59	trace	4·1	pr_0 9h, 10h & 13h.
22	01·8	W	5	39	50	46	0·21	8·2	r_0–r 4h–7h, q 6h.
23	00·3	NW	5	36	49	50	0·06	6·1	r_0 6h–8h, pr 14h.
24	01·9	NW	3	31	48	50	—	7·6	
25	09·5	N	3	35	43	52	0·02	4·2	f 2h, pr_0s_0 17h & 18h.
26	20·1	NNE	6	35	43	68	trace	0·0	pr_0 4h, 7h & 9h.
27	11·1	N	4	35	41	82	0·06	0·0	ir_0–d_0 6h–17h, r_0 19h–
28	04·9	WNW	2	37	42	80	0·04	0·0	id_0 13h–24h. [22h.
29	08·3	SSE	1	34	50	70	—	4·5	
30	10·7	ENE	4	38	51	52	—	4·5	
31	1011·9	ENE	4	40	56	58	—	5·7	
*	1016·7	—		39	49	62	1·00	3·0	* Means or Totals.

General Rainfall for March 1939

	Per cent.
England and Wales	88
Scotland	102
Ireland	104
British Isles	95

Rainfall : March, 1939 : England and Wales

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
Lond .	Camden Square......	1·32	72	*War* .	Birminghm, Edgbaston	1·64	86
Sur .	Reigate, Wray Pk. Rd.	1·66	71	*Leics* .	Thornton Reservoir...	2·06	112
Kent .	Tenterden, Ashenden.	2·12	99	,, .	Belvoir Castle........	1·85	102
,, .	Folkestone, I. Hospital	2·31	..	*Rut* .	Ridlington	1·80	103
,, .	Margate, Cliftonville..	1·72	108	*Lincs*.	Boston, Skirbeck.....	1·98	127
,, .	Eden'bdg.,Falconhurst	1·42	57	,, .	Cranwell Aerodrome..	1·95	139
Sus .	Compton, Compton Ho	1·63	59	,, .	Skegness, Marine Gdns	1·79	108
,, .	Patching Farm........	1·56	73	,, .	Louth, Westgate.....	2·24	106
,, .	Eastbourne, Wil. Sq..	1·46	65	,, .	Brigg, Wrawby St....	2·01	..
Hants.	Ventnor, Roy.Nat.Hos.	1·49	73	*Notts* .	Mansfield, Carr Bank..	1·83	88
,, .	Southampton, East Pk	1·31	57	*Derby*.	Derby, The Arboretum	1·37	77
,, .	Ovington Rectory....	1·52	59	,, .	Buxton, Terrace Slopes	3·43	83
,, .	Sherborne St. John...	1·34	60	*Ches* .	Bidston Obsy.........	1·56	82
Herts .	Royston, Therfield Rec	2·09	114	*Lancs*.	Manchester, Whit. Pk.	1·60	71
Bucks.	Slough, Upton........	1·25	71	,, .	Stonyhurst College...	2·30	62
Oxf .	Oxford, Radcliffe.....	1·57	95	,, .	Southport, Bedford Pk	1·88	84
N'hant	Wellingboro,Swanspool	1·59	89	,, .	Ulverston, Poaka Beck	3·04	78
,, .	Oundle	1·30	..	,, .	Lancaster, Greg Obsy.	2·06	65
Beds .	Woburn, Exptl. Farm.	1·74	101	,, .	Blackpool	2·16	91
Cam .	Cambridge, Bot. Gdns.	1·70	116	*Yorks*.	Wath-upon-Dearne ...	1·93	111
,, .	March	1·34	85	,, .	Wakefield,Clarence Pk.	1·81	101
Essex.	Chelmsford,CountyGns	1·56	90	,, .	Oughtershaw Hall....	5·23	..
,, .	Lexden Hill House....	1·58	..	,, .	Wetherby, Ribston H.	..	..
Suff .	Haughley House.....	1·79	..	,, .	Hull, Pearson Park...	2·35	129
,, .	Rendlesham Hall.....	2·00	119	,, .	Holme-on-Spalding ...	2·14	118
,, .	Lowestoft Sec. School.	1·99	124	,, .	Felixkirk, Mt. St. John	2·43	123
,, .	Bury St. Ed.,WestleyH	2·52	133	,, .	York, Museum.......	1·79	107
Norf..	Wells, Holkham Hall.	1·95	120	,, .	Pickering, Houndgate.	2·60	131
Wilts .	Porton, W.D. Exp'lStn	·99	50	,, .	Scarborough.......	1·83	102
,, .	Bishops Cannings	1·67	74	,, .	Middlesbrough.......	2·03	129
Dor .	Weymouth, Westham.	..	..	,, .	Baldersdale, Hury Res.	3·77	122
,, .	Beaminster, East St ..	1·55	53	*Durh* .	Ushaw College.......	2·69	122
,, .	Shaftesbury	1·10	47	*Nor* .	Newcastle, Leazes Pk.	3·16	153
Devon.	Plymouth, The Hoe...	1·19	41	,, .	Bellingham, Highgreen	3·94	134
,, .	Holne, Church Pk.Cott	2·32	43	,, .	Lilburn Tower Gdns..	3·16	119
,, .	Teignmouth, Den Gdns	1·54	59	*Cumb*.	Carlisle, Scaleby Hall.	2·74	112
,, .	Cullompton	1·29	47	,, .	Borrowdale,Seathwaite	11·50	110
,, .	Sidmouth, U.D.C.....	·95	..	,, .	Thirlmere,DaleHeadH.	7·37	110
,, .	Barnstaple,N. Dev.Ath	1·43	55	,, .	Keswick, High Hill...	5·58	124
,, .	Dartm'r,Cranmere P'l	3·60	..	,, .	Ravenglass, The Grove	3·00	97
,, .	Okehampton, Uplands.	1·74	42	*West* .	Appleby, Castle Bank.	3·10	116
Corn .	Redruth, Trewirgie...	2·21	61	*Mon* .	Abergavenny, Larchf'd	1·83	60
,, .	Penzance, MorrabGdns	2·02	63	*Glam* .	Ystalyfera, Wern Ho..	3·19	60
,, .	St. Austell, Trevarna..	2·40	70	,, .	Treherbert, Tynywaun	4·05	..
Soms .	Chewton Mendip.....	1·93	54	,, .	Cardiff, Penylan......	1·69	54
,, .	Long Ashton	1·67	66	*Carm* .	Carmarthen,M.&P.Sc.	4·11	104
,, .	Street, Millfield	1·24	62	*Card* .	Aberystwyth	2·39	..
Glos .	Blockley	1·73	..	*Rad* .	Bir. W. W. Tyrmynydd	4·29	80
,, .	Cirencester, Gwynfa ..	2·11	91	*Mont* .	Lake Vyrnwy........	4·04	94
Here .	Ross-on-Wye	1·23	61	*Flint* .	Sealand Aerodrome...	1·67	97
,, .	Kington, Lynhales....	1·42	58	*Mer* .	Blaenau Festiniog....	4·58	59
Salop .	Church Stretton......	2·63	..	,, .	Dolgelley, Bontddu...	3·92	80
,, .	Shifnal, Hatton Grange	1·49	81	*Carn* .	Llandudno	2·06	101
,, .	Cheswardine Hall	1·52	72	,, .	Snowdon, L. Llydaw 9	11·25	..
Worc .	Malvern, Free Library.	1·37	71	*Ang* .	Holyhead, Salt Island.	2·58	98
,, .	Ombersley, Holt Lock.	1·17	69	,, .	Lligwy..............	3·28	..
War .	Alcester, Ragley Hall.	1·44	84	*I.Man*	Douglas, Boro' Cem...	3·28	111

Rainfall: March 1939: Scotland and Ireland

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
Guern.	St.PeterP't.GrangeRd.	2·24	91	*R&C.*	Stornoway, C.G.Stn.	4·08	105
Wig	Pt. William, Monreith	2·64	93	*Suth*	Lairg	3·17	102
,,	New Luce School	4·94	140	,,	Skerray Borgie	3·36	..
Kirk	Dalry, Glendarroch	5·27	117	,,	Melvich	2·25	79
Dumf.	Eskdalemuir Obs	..	..	,,	Loch More, Achfary	5·87	91
Roxb	Hawick, Wolfelee	4·26	127	*Caith*	Wick	1·95	86
,,	Kelso, Broomlands	2·63	135	*Ork*	Deerness	2·30	82
Peeb	Stobo Castle	2·85	98	*Shet*	Lerwick Observatory	3·01	95
Berw	Marchmont House	2·92	110	*Cork*	Cork, University Coll.	2·93	98
E.Lot.	North Berwick Res	1·70	90	,,	Roches Point, C.G.Stn.	2·60	86
Midl	Edinburgh, Blackfd. H	2·51	127	,,	Mallow, Waterloo	3·27	113
Lan	Auchtyfardle	3·43	..	*Kerry*	Valentia Observatory	3·63	80
Ayr	Kilmarnock, Kay Park	3·52	..	,,	Gearhameen	6·70	83
,,	Girvan, Pinmore	4·97	132	,,	Bally McElligott Rec.	2·55	..
,,	Glen Afton, Ayr San.	5·96	142	,,	Darrynane Abbey	3·01	74
Renf	Glasgow, Queen's Park	3·91	150	*Wat*	Waterford, Gortmore	1·93	71
,,	Greenock, Prospect H.	4·40	95	*Tip*	Nenagh, Castle Lough	3·17	103
Bute	Rothesay, Ardencraig	4·11	114	,,	Cashel, Ballinamona	2·41	89
,,	Dougarie Lodge	3·33	95	*Lim*	Foynes, Coolnanes	..	..
Arg	Loch Sunart, G'dale	5·32	96	,,	Limerick, Mulgrave St.	2·74	93
,,	Ardgour House	7·37	..	*Clare*	Inagh, Mount Callan	4·13	..
,,	Glen Etive	7·64	97	*Wexf*	Gorey, Courtown Ho.	2·41	104
,,	Oban	3·64	..	*Wick*	Rathnew, Clonmannon	2·62	..
,,	Poltalloch	4·23	110	*Carl*	Bagnalstown FenaghH	2·34	96
,,	Inverary Castle	6·63	105	,,	Hacketstown Rectory	2·89	103
,,	Islay, Eallabus	3·59	94	*Leix*	Blandsfort House	3·26	124
,,	Mull, Benmore	7·65	72	*Offaly*	Birr Castle	2·70	112
,,	Tiree	2·74	82	*Kild*	Straffan House	..	..
Kinr	Loch Leven Sluice	2·75	92	*Dublin*	Dublin, Phoenix Park	2·76	142
Fife	Leuchars Aerodrome	2·06	106	*Meath*	Kells, Headfort	3·09	112
Perth	Loch Dhu	..	..	*W.M*	Moate, Coolatore	2·37	..
,,	Crieff, Strathearn Hyd.	2·67	83	,,	Mullingar, Belvedere	2·78	103
,,	Blair Castle Gardens	2·78	106	*Long*	Castle Forbes Gdns	2·66	90
Angus	Kettins School	2·00	82	*Gal*	Galway, Grammar Sch.	2·22	74
,,	Pearsie House	2·62	..	,,	Ballynahinch Castle	3·03	59
,,	Montrose, Sunnyside	2·42	116	,,	Ahascragh, Clonbrock	2·86	86
Aber	Balmoral Castle Gdns.	2·68	94	*Rosc*	Strokestown, C'node	2·43	88
,,	Logie Coldstone Sch	..	..	*Mayo*	Blacksod Point	3·54	86
,,	Aberdeen Observatory	1·97	82	,,	Mallaranny	4·09	..
,,	New Deer SchoolHouse	2·86	110	,,	Westport House	2·93	75
Moray	Gordon Castle	2·17	94	,,	Delphi Lodge	5.98	72
,,	Grantown-on-Spey	2·01	76	*Sligo*	Markree Castle	3·41	99
Nairn	Nairn	1·74	93	*Cavan*	Crossdoney, Kevit Cas.	2·51	..
Inv's	Ben Alder Lodge	5·25	..	*Ferm*	Crom Castle	3·14	101
,,	Kingussie, The Birches	2·81	..	*Arm*	Armagh Obsy	3·02	129
,,	Loch Ness, Foyers	..	..	*Down*	Fofanny Reservoir	5·52	..
,,	Inverness, Culduthel R	1·88	85	,,	Seaforde	3·51	120
,,	Loch Quoich, Loan	13·89	..	,,	Donaghadee, C. G. Stn.	2·79	127
,,	Glenquoich	11·19	115	*Antr*	Belfast, Queen's Univ	3·96	155
,,	Arisaig House	4·43	95	,,	Aldergrove Aerodrome	3·61	144
,,	Glenleven, Corrour	6·17	106	,,	Ballymena, Harryville	4·74	150
,,	Ft. William, Glasdrum	..	..	*Lon*	Garvagh, Moneydig	3·97	..
,,	Skye, Dunvegan	5·95	..	,,	Londonderry, Creggan	5·17	162
,,	Barra, Skallary	3·45	..	*Tyr*	Omagh, Edenfel	3·96	126
R&C.	Tain, Ardlarach	2·75	111	*Don*	Malin Head	3·78	131
,,	Ullapool	2·74	66	,,	Dunfanaghy	..	..
,,	Achnashellach	..	..	,,	Dunkineely	3·76	..

Climatological Table for the British Empire, October 1938

STATIONS.	PRESSURE. Mean of Day M.S.L. (mb.)	PRESSURE. Diff. from Normal. (mb.)	TEMPERATURE. Absolute. Max. (°F.)	TEMPERATURE. Absolute. Min. (°F.)	TEMPERATURE. Mean Values. Max. (°F.)	TEMPERATURE. Mean Values. Min. (°F.)	TEMPERATURE. Mean Values. ½ Max. and Min. (°F.)	TEMPERATURE. Mean Values. Diff. from Normal. (°F.)	TEMPERATURE. Mean. Wet Bulb. (°F.)	Relative Humidity. (%)	Mean Cloud Am'nt (0–10)	PRECIPITATION. Am'nt. (in.)	PRECIPITATION. Diff. from Normal. (in.)	PRECIPITATION. Days.	BRIGHT SUNSHINE. Hours per day.	BRIGHT SUNSHINE. Percentage of possible.
London, Kew Obsy	1012·6	− 1·4	64	33	57·2	45·3	51·3	+ 0·4	46·3	89	7·3	2·06	− 0·64	15	3·6	33
Gibraltar	1017·1	− 0·1	76	53	70·2	60·7	65·5	− 0·9	59·4	81	5·5	1·35	—	5	—	—
Malta	1016·8	+ 0·8	79	58	75·1	66·1	70·6	− 0·3	64·8	76	4·6	1·24	− 1·63	8	7·1	63
St. Helena	1018·6	− 0·4	61	51	58·5	53·4	55·9	− 1·6	55·0	99	9·9	3·06	+ 1·75	25	—	—
Freetown, Sierra Leone	1012·3	+ 2·4	91	71	85·8	73·5	79·7	—	73·5	91	7·5	12·83	+ 0·21	23	—	—
Lagos, Nigeria	1011·6	+ 0·6	88	69	84·4	73·0	78·7	− 1·0	76·0	91	7·4	8·62	+ 0·85	18	5·4	45
Kaduna, Nigeria	1010·8	—	93	57	89·7	64·9	77·3	− 0·4	70·4	79	4·4	1·16	− 1·59	4	8·5	71
Zomba, Nyasaland	1010·5	− 0·3	93	59	85·9	66·1	76·0	+ 1·9	68·2	61	5·5	0·42	− 1·10	2	—	—
Salisbury, Rhodesia	1010·8	− 0·4	91	51	84·4	59·0	71·7	+ 1·0	58·7	41	0·9	0·71	—	5	10·1	81
Cape Town	1018·3	+ 0·9	81	42	70·0	52·1	61·1	− 0·1	55·9	77	5·0	2·41	+ 0·76	10	—	—
Johannesburg	1013·8	+ 0·7	83	43	74·5	52·3	63·4	+ 0·6	54·4	63	5·2	2·84	+ 0·28	15	8·1	64
Mauritius	1019·8	+ 1·6	83	62	79·9	66·4	73·1	+ 0·4	66·6	61	5·5	0·83	− 0·84	20	8·9	71
Calcutta, Alipore Obsy.	1007·7	− 1·7	96	65	91·1	75·0	83·1	+ 3·8	76·8	86	4·0	3·77	− 1·13	6*	—	—
Bombay	1008·8	− 1·0	93	71	84·9	74·2	79·5	− 2·9	74·2	83	4·6	15·17	+13·50	7*	—	—
Madras	1008·3	− 0·6	97	71	91·8	76·4	84·1	+ 1·8	74·4	84	5·7	7·90	− 3·25	7*	—	—
Colombo, Ceylon	1011·0	+ 1·0	89	69	85·3	74·2	79·7	− 0·8	76·0	74	6·8	4·86	− 8·50	16	8·1	67
Singapore	1009·8	+ 0·1	89	72	86·2	75·3	80·7	− 0·4	77·8	77	7·6	6·33	− 1·74	14	5·9	49
Hongkong	1012·0	− 1·7	89	66	82·7	73·9	78·3	+ 1·4	72·6	72	5·0	6·09	+ 1·15	12	7·5	65
Sandakan	1009·0	—	90	72	87·3	74·8	81·1	− 0·3	74·4	92	8·2	11·41	+ 1·08	18	—	—
Sydney, N.S.W.	1016·7	+ 1·9	89	52	72·0	58·2	65·1	+ 1·5	60·8	66	6·7	2·93	+ 0·08	12	5·5	43
Melbourne	1016·4	+ 1·6	87	41	71·6	48·3	59·9	+ 2·2	53·1	55	6·4	1·18	− 1·45	9	7·1	55
Adelaide	1017·6	+ 1·6	97	42	74·8	50·4	62·6	+ 0·7	54·6	43	5·7	0·70	− 1·04	4	7·4	57
Perth, W. Australia	1017·7	+ 0·9	85	44	70·5	52·2	61·3	+ 0·5	54·7	63	4·2	1·75	− 0·47	10	8·8	69
Coolgardie	1014·3	− 0·6	98	46	79·9	53·0	66·5	+ 2·8	55·2	48	2·4	0·00	− 0·66	0	—	—
Brisbane	1018·6	+ 2·4	86	55	78·6	61·3	69·9	+ 0·1	64·7	65	5·3	3·45	+ 0·92	8	8·9	70
Hobart, Tasmania	1012·3	+ 2·0	85	37	64·3	46·4	55·3	+ 1·2	49·4	57	6·2	1·83	− 0·43	13	6·5	49
Wellington, N.Z.	1015·5	+ 2·4	67	40	60·5	48·3	54·4	0·0	51·7	72	5·9	3·25	− 0·83	10	7·0	53
Suva, Fiji	1014·2	+ 1·0	89	68	82·3	71·8	77·1	+ 1·3	72·7	83	7·3	19·61	+11·32	21	4·2	34
Apia, Samoa	1012·5	+ 1·0	87	69	84·9	73·8	79·3	+ 0·9	75·3	73	5·4	8·04	+ 1·66	15	9·3	75
Kingston, Jamaica	1011·2	− 0·3	93	70	88·5	73·4	80·9	+ 0·4	72·3	86	3·6	3·26	− 4·20	4	7·7	65
Grenada, W.I.	1010·3	− 0·5	90	70	86	73	79·5	− 0·6	73	74	5	13·10	+ 5·34	26	—	—
Toronto	1020·3	+ 2·8	82	33	60·4	43·8	52·1	+ 3·5	44·4	86	5·5	1·03	− 1·54	9	6·2	56
Winnipeg	1015·9	+ 1·0	82	21	59·6	37·4	48·5	+ 7·8	37·4	76	4·7	0·40	− 0·97	5	5·3	49
St. John, N.B.	1018·3	+ 2·5	75	32	56·5	42·3	49·4	+ 4·1	44·0	87	5·8	2·38	− 2·16	13	5·3	48
Victoria, B.C.	1016·1	− 1·0	65	39	57·2	46·1	51·7	+ 1·4	47·9	76	6·6	2·61	+ 0·04	16	4·6	42

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Winnipeg	1015·9	+ 1·0	82	21	59·6	37·4	48·5	+ 7·8	37·4	76	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
St. John, N.B.	1018·3	+ 2·5	75	32	56·5	42·3	49·4	+ 4·1	44·0	87	5·8	2·38	− 2·16	13	5·3	48
Victoria, B.C.	1016·1	− 1·0	65	39	57·2	46·1	51·7	+ 1·4	47·9	76	6·6	2·61	+ 0·04	16	4·6	42